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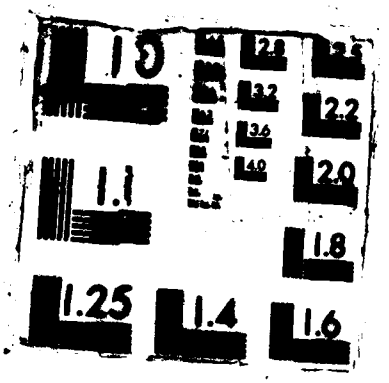
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This document constitutes the final report on a Department of Defense University Research Instrumentation Program (URIP) Grant to Syracuse University. The grant provided funds for the purchase of a VAX 11/780 to create a Laboratory for Systems Automation Through Artificial Intelligence.

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NEW YORK STATE CENTER FOR ADVANCED TECHNOLOGY IN COMPUTER APPLICATIONS AND SOFTWARE ENGINEERING

FINAL REPORT - GRANT NO. AFOSR-85-0065

February 24, 1986

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INTRODUCTION

This is our Final Report on contract AFSOR-85-0065 between the Air Force Office of Scientific Research (AFOSR) and the New York State Center for Advanced Technology in Computer Applications and Software Engineering (CASE Center) at Syracuse University. This grant program provided $274,028 from AFOSR toward the purchase of a VAX 11/780 computer system to create a laboratory for Systems Automation Through Artificial Intelligence. Presented here are descriptions of research projects conducted through the Artificial Intelligence Consortium, a listing of the equipment and peripherals installed, and summaries of the research programs that are being carried out using this computer facility.

ARTIFICIAL INTELLIGENCE CONSORTIUM

One of the major research-related activitiesof the CASE Center over the past year included establishment of the Artificial Intelligence Consortium, sponsored by the Rome Air Development Center at a funding level of over $8 million over five years. The purposes of the Artificial Intelligence Consortium are (1) to increase basic research capabilities and activities in artificial intelligence (AI) at participating academic institutions, (2) to apply AI techniques to problems of mutual interest, and (3) to increase the research and teaching resources available for education and training of new AI researchers and practitioners, particularly at the Rome Air Development Center.

The Systems Automation Through Artificial Intelligence facility is used extensively in the Syracuse University based research projects associated with the Artificial Intelligence Consortium. Following are brief abstracts of these projects.

Projects · Software and Hardware Architectures for Increasing Performance of Very Large Knowledge-Based Systems

P. Bruce Berra, Professor, Electrical & Computer Engineering

This project consists of two tasks, the first of which is to develop advanced software and hardware architectures for knowledge-based systems that are sufficient to overcome fundamental limitations in current techniques for implementing, managing, and maintaining knowledge bases. This first task is approached by seeking new software and hardware techniques to enhance the performance of systems that manage knowledge through use of logic, production rules, semantic networks, and frames. Since management of a very large knowledge base is a fundamental problem within a knowledge-based system, it is intended that this phase of the project concentrate initially on exploiting the relatively well-developed fields of database management and database machines.

The second task is a subset of the first. It consists of research leading to software and hardware architectures that support efficient logic programming. Ways are sought to exploit inherent parallelism, eliminate processing

bottlenecks, and implement unique secondary storage organizations pertinent to logic programming systems.

Project: Knowlege Base Maintenance Using Logic Programming Methodologies

Kenneth A. Bowen, Professor, Computer & Information Science

The knowledge bases used to support Air Force missions over the next decade will assist both human and automated experts to perform various tasks ranging from logistical support to C3I and intelligence analysis. In these latter two examples, the knowlege bases will be large, complex, and highly volatile. This project addresses the problem of providing basic automated machinery for the management of such knowledge bases, especially the maintenance of consistency and integrity constraints. The work is carried out from the point of view of certain logic programming systems, namely the "meta-level" systems, primarily embodied in a system called metaProlog.

EQUIPMENT

In order to establish this research facility, the following equipment has been purchased, delivered and installed:

No.	Unit Description	Cost
	Vendor: Digital Equipment Corporation	**$287,662**
1	VAX 11/780 Standard System, with Fixed Disk and Controller and Magnetic Tape Drive	
1	MS780-FA 2MB (64K) ECC MOS Expansion Memory	
1	MS780-FB 4MB Expansion Memory	
2	DMF32-M Communications Controllers	
1	DF100-RM Modem Enclosure	
1	DF100-PR Power Regulator	
1	DW780-AA Unibus Adaptor	
1	BA11-KU Expansion Box	
3	DD11-DK Expansion Backplanes	
1	H7007-AC Surge Suppressor	
1	H7007-AB Surge Suppressor	
2	CK-DMF32-LDCAB Kit Multifunction GNL	
4	VT220-AA A/N Video Terminals	
7	VT220-C2	
3	VT22K-AA	
4	VT22K-A Country Kits	
3	DF03-RA 300/1200 Modems	
1	DF03-RC 300/1200 Auto Call Modem	
3	DF112-AM 300/1200 Sync/Asyn Rack Modem	
1	DF112-AM Modem in a DF100-D	
2	RA81-AA 456 MB 16B Disk, 12-OV/60, NO C	

No.	Unit Description	Cost
1	LA120 printer/terminal	
1	DZ11-M 8-Line Asynch. Multiplexer	
1	CK-DZ11-DD RS232 Kit	
	insurance	
	Vendor: Advanced Electronic Design Inc.	**$ 49,913**
5	AED 767T8A6 - 767 Table Top Color Graphics Terminals	
5	AED 767M06A6 - 19" Diagonal Long Persistence Monitors	
	Vendor: RG Engineering	**$ 4,945**
1	Bit Pad One, 15" x 15" with RS-232 Interface, Controller, Biasing Device, and Manual	
5	Four Button Cursors	
1	Standard Wall Mount Power Supply and 10' Interface Cable	
3	Bit Pad Two, 11" x 11" with RS-232 Interface, Controller, and Technical Reference Manual	
4	Power Supplies and Cables	
	Vendor: ATT	**$ 400**
1	CPU License for UNIX System	
	Vendor: University of California - Berkeley	**$ 750**
1	UNIX License	
	Vendor: Hewlett-Packard Corporation	**$ 19,977**
1	7586B Option 065 Drafting Plotter	
1	7475A 6 Pen Graphics Plotter	
	Vendor: Imagen Corporation	**$ 13,915**
1	Model 8/300 Laser Printer System, 512Kbytes memory	
1	Additional 512Kbytes memory for Printer	
1	Firmware Maintenance	
1	DIMP Host Software Support for Printer	
1	Additional Paper Tray for Model 8/300 Printer	
4	Print Cartridges for Printer	
1	SDM Canon Laser Printer Engine	
	Vendor: Dunn Instruments (Bartlett Assoc.)	**$ 4,815**
1	Microcolor Film Recorder	
1	4" x 5" Film Back	

No.	Unit Description	Cost
	Vendor: Specialized Products Co.	$ 933
1	SPC55ED Tool Kit	
1	475S270 Datacheck II	
1	400S250 MT-1 Minitracker	
1	400S100, 400S105 Gender Changers	
1	260-7 PRT VOM (Simpson)	
	Extra Leads	
1	070S116 Screwdriver Set	
1	070S200 Phillips Screwdriver Set	
	Vendor: SUACS (Local Supplies)	$ 290
	Cables and Connectors for AED767	
	Coax Cables for Film Recorder	
	Cables and Connectors for VT220s	
	TOTAL EXPENDITURES	$383,600*

*TOTAL includes both Department of Defense and Syracuse University contributions to this facility. In addition, Syracuse University provided $175,000 for site preparation, $34,715 for contract maintenance, over $5,000 for software, $13,628 for temporary personnel, and $9,646 for small hardware and supplies.

There have been some changes to the configuration of the system as outlined in the proposal to the Department of Defense. The DZ11-DP communications interfaces were replaced by DMF32 communication controllers that provide more lines of access, and the DF02-AC modems were replaced with DF112 modems, which are upgraded models. A reevaluation of the graphics needs of the system, showed that the Imagen 8/300 Laser Printer was equivalent to the Versatec plotter for small plots and better for text output purposes, and, in combination with the smaller HP 7475 plotter, would better serve the researchers using the system.

The faculty members involved in research programs using this computing system have formed a VAX Management Committee to oversee the operation of the facility and effort is being made to set up a state-of-the-art VLSI CAD tool set. The faculty members have trained a sufficient number of students in VLSI design methodologies. In addition, the CASE Center is hiring a programmer to supervise day-to-day activities.

RESEARCH PROJECTS

There are a variety of ongoing research efforts being conducted at the CASE Center that are able to make extensive use of this computing system. Following are brief descriptions of current research projects associated with the Systems Automation facility.

Project: New Generation Knowledge Processing
RADC Contract #F30602-84-K-0001

J. Alan Robinson, University Professor and Research Advisor
CASE Center

This research project provides support for J.A. Robinson, Professors E.E. Sibert and K.A. Bowen from the School of Computer and Information Science, and a postdoctoral fellow in Computer & Information Science. The current fellow, Kevin J. Greene, a postdoctoral researcher in the artificial intelligence area, is also supported in part by the CASE Center.

The objective of the project is to design and implement an ultra-high- level programming system called SUPER (Syracuse University Parallel Expression Reduction). The system will consist of a programming language and a multi-processor architecture.

This contract supports development of a successor to the LOGLISP language and a machine to run programs written in this language. The SUPER language is based on reduction semantics and will subsume both (pure) LISP and (pure) PROLOG. The machine will be a non-von Neumann design based on highly parallel graph reduction. The architecture may be similar to that of the Alics system at Imperial College, London.

Current work is at the advanced design stage, in preparing simulations in OCCAM for possible hardware implementation experiments making use of the INMOS "Transputer" microcomputer chip. A fully lazy higher-order purely functional language, LNF (Lazy Normal Form), has been designed and implemented experimentally on a LISP machine. A simulator for the RED2 Machine, the hardware system designed by Klaus Berkling to support the SUPER language, has been implemented. In addition, custom chips have been designed and fabricated for an associative memory component of the Syracuse University Machine for Associative Computation (SUMAC).

Project: Syracuse University Machine for Associative Computation (SUMAC)

John V. Oldfield, Professor of Electrical & Computer Engineering
Chairman, VAX Management Committee

The SUMAC project aims to develop efficient implementation mechanisms for relational and functional programming languages. Particular attention is being paid to content-addressable memories (CAMs), and to higher-level concurrent

processing. The CAM is a well-established memory device, but its applications have been very restricted in size, due to technology limitations. Present-day VLSI techniques allow CAMs to be built with sufficient width for logic programming applications such as variable binding, and such CAMs are readily cascaded to form substantial memories with extremely fast search times. In earlier work, attention was focused on the common logic programming operations of Unification and Resolution, and this focus led to the Syracuse Unification Machine (SUM). SUM is intended as a coprocessor to an existing LISP machine running LOGLISP. It includes a Binding Agent to hold variable-expression bindings, which are maintained in the form of a stack. The variables are held in the CAM position, while corresponding expressions are held in RAM (random access memory). The required CAM chip was originally designed in nMOS for the MOSIS 4-micron process, and a prototype has been successfully designed, fabricated, and tested. A CMOS version for the MOSIS 1.2 micron process is in fabrication.

A comprehensive review of the SUM architecture showed that the interface to the LISP machine host, and to list structures held in the host, was a major bottleneck. The SUMAC group is now reviewing wider aspects of the logic programming execution cycle, and has found other applications for CAMs, including graph structure representation and operations such as path compression, list membership, redex identification, and graph transformation. SUMAC is intended to be much more comprehensive than SUM in that it will provide a complete execution mechanism for logic and functional programs. The resulting machine will exploit the parallelism inherent in logic programs, as well as the search-parallelism, efficient structure representation, access, and garbage collection afforded by associative memories.

A prototype Associative Processor is under development with support from IBM and will be used to further develop the associative algorithms on which SUMAC will be based (the project under Professor Oldfield's direction, "Improving the Execution Rate of Logic Programming"). In addition, the Inmos Transputer (along with the associated OCCAM language) is being evaluated in view of its applicability to concurrent processing.

While support for this project is currently being provided by the CASE Center, proposals to GE and DARPA are pending.

Project: Computer Aids for Conceptualizing and Designing Space Structures

John V. Oldfield, Professor of Electrical and Computer Engineering
Francois Gabriel, Professor of Architecture

The object of this project is to design a new computer program specifically for the needs of the space structure designer. Among the various types of space structures, the space frame is the only one that is practical for multi-story buildings. The potential of space frames for tall buildings is remarkable, so the field of study is of considerable amplitude.

Space frame structures are made of multiple octahedral frames which correspond to a six-directional space-lattice. Conventional drawing techniques are inadequate for the quick and precise representation of this type of lattice. Rather, the design of tall structures integrated with space frames depends on the development of specific graphic techniques. The computer program will incorporate an appropriate data structure, a hidden-surface algorithm and interactive means of graphic input. The program will be implemented on existing state-of-the-art facilities.

Project: Development of a Reduction Machine

Klaus J. Berkling, Research Professor, CASE Center

The goal of this project is to construct a very high-level "new generation" architecture that will support symbolic computation in general. In particular, it will provide support for a language embodying both function programming (lambda calculus) and logic programming (predicate calculus) in a simple architecture whose main features correspond directly to those of the language itself. The meaning of expressions of the language is given by reduction rules. Computation consists of reducing a given (input) expression by methodically rewriting it according to these rules until an (output) expression is obtained.

Dr. Berkling constructed a machine on these lines in Germany several years ago (the RED1 Machine) and successfully demonstrated a direct hardware realization of the fundamental beta reduction rule of the lambda calculus, which is the main rule governing pure LISP. In this project is to develop the successor to the RED1 machine, RED2, which will extend the RED1 design in several directions.

1. Whereas RED1 was a single-processor system, performing one reduction at a time, RED2 will be a multi-processor system exploiting the fact that in general an expression contains many subexpressions ready to be rewritten independently of each other.

2. RED2 will augment RED1 by adding new rules to deal with resolution and unification, thus combining functional programming capabilities with logic programming capabilities.

3. Whereas RED1 was a pure string-reduction system, RED2 will be a graph-reduction system, emphasizing the sharing of common structures through pointers.

This project is currently supported by the CASE Center and Syracuse University. Dr. Berkling has submitted proposals to both GE and DARPA, and it is expected that he will receive external support from either or both of these sources during the coming year.

Project: Development of a Delphi to PROLOG Compiler

Kenneth A. Bowen, Professor, School of Computer and Information Science

This project's purpose was to understand and implement the capabilities of "expert systems" within PROLOG. The task directly supported a General Electric project at the Electronics Laboratory in Syracuse to develop a high-performance embedded processor for expert systems.

Delphi, a proprietary General Electric expert system framework, provides several features desirable in an expert system. However, its speed is inadequate for important applications for which it is otherwise well suited. The performance can be improved to the point where applications are feasible by development of a Delphi to Warren instruction set compiler. The particular capabilities that PROLOG lacks which must be developed include certainty measures, forward chaining, and explanation facilities. This complier may be developed by initially developing an interpreter for rules with these Delphi characteristics, and subsequently converting this to a compiler to the Warren instruction set.

Project: Rheumatology Knowledge Base and Expert System

Kenneth A, Bowen, Professor of Computer & Information Science
Lorne A. Runge, Associate Professor, Upstate Medical Center

Two faculty members from the CASE Center Consortium, assisted by a CASE-supported graduate student, are using PROLOG and its extensions to contruct expert systems and knowledge bases in medicine. Their initial area of concentration is rheumatology.

Among the earliest successful expert systems were several concerned with medicine, including MYCIN, CASNET, and a digitalis dosage advisor. The success of these systems is twofold: they perform nearly as well as human experts in their restricted domains of expertise and they are very useful in medical education. Both aspects of success rest heavily on the rule-based nature of the systems. The limitations of the systems in each area--performance and education--are due in large part to the essentially phenomenological form in which expert systems express medical knowledge. Most researchers in this area agree that to make further progress, the hierarchical and causal structure of medical knowledge must be better represented. Diagnosis and treatment of rheumatoid arthritis, for example, require thorough understanding of the causes and the effects of the disease.

This project explores this hierarchical and causal structure in the area of rheumatology. The researchers must consider not only the phenomena that characterize a disease but also the basic physiological processes involved in its development. Their experiments make use of both microPROLOG on personal computers and full PROLOG and its extensions (metaPROLOG) on mainframe computers. As one long-term goal of their work, the researchers envision small expert systems running on personal computers that have access, through

networks, to powerful expert systems and large data bases running on large mainframes.

Project: Investigation of Data Base Management Systems

P. Bruce Berra, Professor, Electrical & Computer Engineering

This project examines Data Base Management System (DBMS) requirements for the support of large production rule-based expert systems. The specific objectives are to investigate various database and expert systems, determine their data and knowledge management needs, and derive a set of requirements necessary to support these real-time systems. The grant includes support for a graduate student.

Project: Computer-Aided Design Data-Base Management

P. Bruce Berra, Professor, Electrical and Computer Engineering

Commercial database management systems (DBMS's) are widely used in business but often perform unsatisfactorily when used in computer- aided design (CAD). Because CAD processes are characterized by complexity, a high degree of dynamism, and large amounts of design information, they require more complex database organizations. The main objective of this project was to investigate database management systems and new computer architectures which have the capability of managing much larger databases at acceptable speeds while maintaining a full range of capabilities for CAD operations. Two reports of the research results were prepared by a graduate student working under Professor Berra: one on issues in these fields and one on distributed systems.

Project: Migration of Scientific Applications Between Different Computer Architectures

Daniel J. Pease, Assistant Professor, Electrical and Computer Engineering

As the number and scope of scientific applications of computer systems increase, it is often desirable, but difficult, to transfer software between computer systems. The first phase of this project identified the scientific applications in which this problem occurs, characterized the various computer systems between which transfers will be made, and investigated alternative transfer techniques. A single technique was designated for use in three selected application areas.

In the next project phase, four software migration aids will be developed to move software from the VAX/CMS environment. These tools include: (1) a FORTRAN migrator; (2) a C migrator; (3) a FORTRAN and C Data Base converter; and (4) a file transfer utility.

Project: Anaren Graduate Student Program

Bradley J. Strait, Director, CASE Center

This project provides stipend and tuition support for one graduate student working in the VLSI design area. The specific task will involve an area of general interest to Anaren Microwave, Inc.

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